Integration of Ubiquitous Computing Technologies: a practical case

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Abstract. This paper describes the experience of Metro de Madrid in the development and use of advanced mobile applications created in order to achieve the ubiquitous of their technicians. The paper is structured in three main areas, the general approach to the work, the first pilots developed and the advances applications. Finally the conclusions obtained are included and some references can be found.

1 Introduction

The mobile technology boom has led many companies to speculate on the future in order to allow their business to become more mobile, which in some companies has brought about a major cultural change, not just in their employees' way of working, but in some cases has led to changes in the firm's organizational structure..

Metro de Madrid, S.A.[1] has been one of the pioneering Spanish companies to provide their employees with diverse mobile software applications to make their jobs easier, which means that they can travel between different business centres and do their job without having to return to their own offices, thus achieving a reduction in response time when making decisions.

An analysis of some of the software applications used in Metro de Madrid, the technologies used, the various devices, the modes of communication used and the advantages that each one brings to the business is given below.

1.1 Equipment Developed in Metro de Madrid

Before embarking on the development of major mobile software applications, Metro started with small pilot schemes for PDA type devices that allowed them to consult business data and produce simple reports of incidents occurring as part of business operations. Some of these software applications were:

– **Incimov:** Provides for viewing on a daily basis the report of incidents for the metro lines and facilities. The software was created using Visual Basic.
– **Incisis:** Allows for downloading reports to keep system managers informed on computer system incidents that occur in the IT Unit. The technology employed to create this software was Tamino Mobile Suite from Software AG[2] .

- **Pagos [payments]:** This software application makes situation reports available on the different electronic payments (automatic ticket vending machines) made in the company. This also used the Tamino Mobile Suite.
- **Gestión de Lineas (GDL) [Line Management]:** This enables queries to be made on the status of Metro de Madrid lines and depots, as well as obtaining detailed information on the units making up each of the trains. Information is shown on the PDA Browser by means of requests to a web applications server providing data in real time, developed in Java[3].

Once familiar with the development of the applications for these terminals and the characteristics of the various technologies, far more ambitious projects were carried out, that were not limited just to data enquiry but that also interacted directly with the data in the ERP system:

- **GEMA:** Is a mobile solution to optimise Management and Maintenance of Fixed Facilities. This software application allows operators to manage maintenance of fixed facilities, to have information on instructions assigned, to work and interact on its operations, allows reprogramming of its activities, depending on severity, as well as providing additional information relative to the work done. Those using the application do so on industrial terminals and the technology used was the SAP Mobile Engine[4].
- **MTTCC:** This application allows the central workshop users to become mobile. Their principal mission is maintenance of Metro's "mobile material" (trains) allowing them to move trains in, out and reposition them in the most effective manner. Development was done using SAP Netwaver Developer Studio[5].

1.2 Development objectives for mobile applications.

As we explained in the beginning, the use of mobile applications may imply a cultural change in the company, with its impact extending to both business development and organisational structure.

The really important issue is for a company to identify those processes that are best suited to being equipped with mobility and to calculate the ROI (Return On Investment) that would be obtained by mobilising a process that up until now has been done in a traditional way. In some cases the ROI obtained is very high, depending on the operability and functionality that the application can provide.

The overriding objective when developing successful solutions is to get the user who is going to use these applications to participate, to best cover and meet his needs. These applications should allow him to access business information and interact with it easily, comfortably and intuitively. In the next sections we will be commenting on the facilities and advantages that each of the software applications provide.

In order for the developed applications to meet the users' needs, it is necessary that there is a perfect understanding between users and analysts/developers, and that, in the end, the anticipated result comes as close as possible to what the user wanted. Metro de Madrid has developed a methodology to meet this premise, incorporating best practice methods. One of the pillars of this methodology is on the one hand requirements capture and management, and on the other a correct definition of interfaces given that there are multiple instances of software applications that are not used because they are neither intuitive nor user friendly.

2 First approach to development of mobile software applications

In this section we are going to look at the first mobile software applications developed by Metro. The development Technologies used for these applications were varied and pilots were designed in Visual Basic, Tamino Mobile (XML) and Java. These pilots allowed us to get a first impression to understand the advantages and disadvantages of each technology for subsequent developments.

2.1 Incimov

Incimov was the first software developed for PDA by Metro de Madrid. This software allows daily downloads and viewing on a daily basis the report of incidents on the metro lines and in all their facilities.

Service suspensions, power supply, train breakdowns, breakdowns in facilities, incidents affecting circulation, trains in service, closure of access to station foyers and stations, and many other business related data are available in the report.

The interface for this software application is Visual Basic, and the downloaded reports are stored in XML. To download the report from a PDA an Internet connection is needed, either through GPRS, Base (cradle) or Wi-Fi.
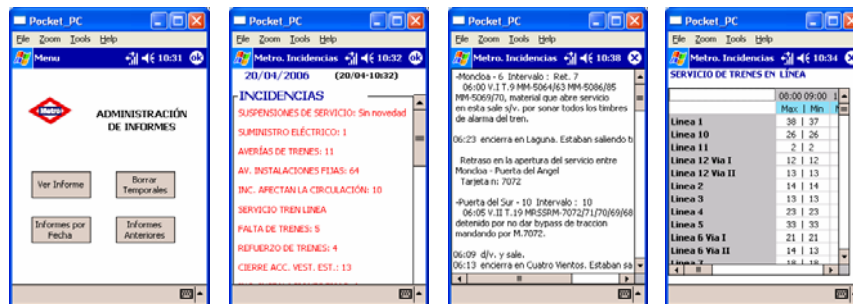

Fig. 1. Four sets of data capture from the Incimov software from the PDA, showing the start-up menu as well as incidents generated on metro lines and trains in service.

2.2 Incisis

Incisis provides for downloading and viewing reports on IT events in the IT Unit. Some of the data obtained in this report are on events that have occurred on Unix/NT servers, such as, communication problems, pending events, pending orders for change, breakdown of access control terminals, stoppages in the ERP system.

Tamino mobile suite was used for this application, which is fully oriented to XML. To download the report from a PDA an internet connection is required either through GPRS, Base (cradle) or Wi-Fi.
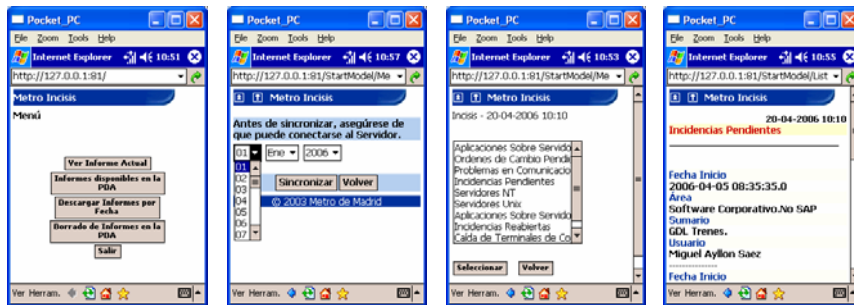
Fig. 2. This image shows a data dump from the PDA of the Incisis application, where you can see the start up menu screens, requests for reports by date, incidents available, as well as more specific data on incidents.
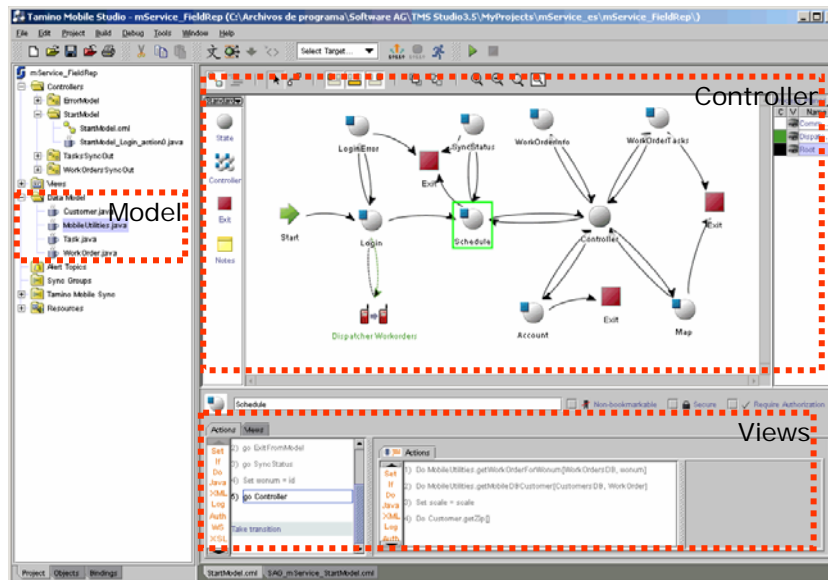

Fig. 3. This data dump shows the development environment based on the "Model-View-Controller" convention of Tamino Mobile Studio.

For this application, a development based on the Model-View-Controller template of the Tamino Mobile Suite [2], was used for the first time, where:

- **Model:** Contains the application's functionality. It defines the behaviour of the objects that represent the process for becoming mobile.
- **View:** Provides the model presentation, representing the appearance of the application in each device.
- **Controller:** Defines the application's operation. This is what reacts to the user's actions, it takes responsibility for presenting each of the views and giving access to the different model classes.

2.3 Electronic Payment

Electronic Payment provides downloading and viewing of reports on the progress of payments made for sales of tickets/season tickets. This report shows all operations, (orders, cancellations, amounts) made throughout a day, distinguishing between the different banking organisations; giving specific details of the banks; ratios of current and accumulated operations and total amounts.

Tamino Mobile Suite was also used in this application. In this case comparative graphics of operations and their evolution are included. To download the report from a PDA an internet connection is needed, whether by GPRS, Base (cradle) or Wi-Fi.
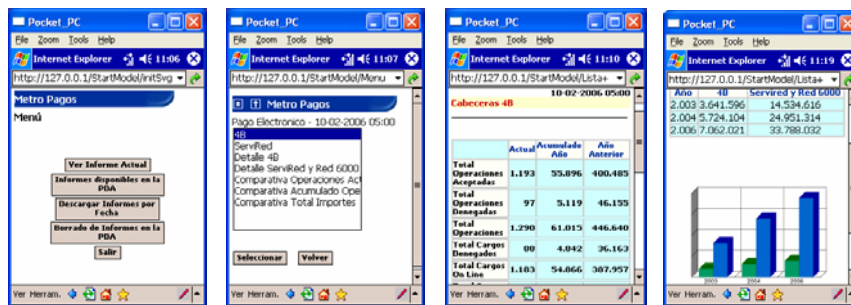

Fig. 4. Four data dumps taken from the PDA are given where one can see the start-up menu screens, as well as data and graphics of transactions progress.

2.4 GDL

GDL (Line Management): Provides for enquiries on the state of trains on all Metro lines and of depots (sheds/workshops) in real time, as well as for obtaining detailed information on the units that make up each of the trains.

There is a server for this software that sends the report on all trains to the PDA on demand, which is shown in html format on the portable equipment's web browser.

To view the GDL in the browser an internet connection is needed, either through GPRS, Base (cradle) or Wi-Fi. For the GPRS connection, or external Wi-Fi to the metro network, a client VPN for the PDA is required, given that the server is internal.
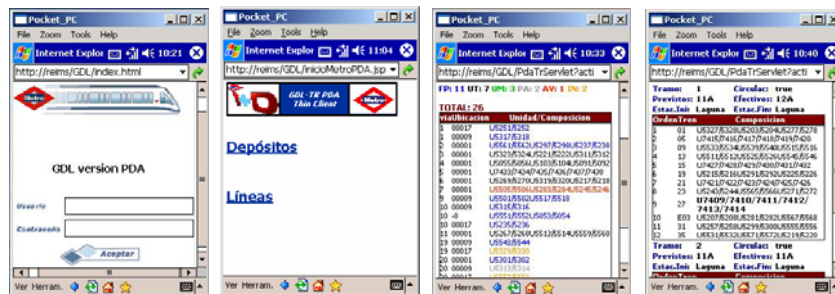

Fig. 5. This shows four data dumps taken from the PDA where you can see the login screen and data dumps of depots and lines.

3 Progress in the development of mobile applications

Once familiar with the different technologies, work started on development of more complex projects, where not only enquiries are made but one can also access the information directly, interact with it and update the data in the system.

3.1 GEMA (Management and Maintenance of Fixed Installations)

This project objective was the installation of a management of maintenance module (SAP module PM), to cover the users' needs for management of the Metro's fixed installations. The module is based around the mobile framework and allows maintenance operatives to have all the necessary information to carry out operations assigned throughout their working day from a ruggedised industrial terminal (PDA type). In addition, the system allows them to re-programme their activities depending on severity and location, as well as to add information in relation to the work done.

The mobile terminal has the SAP Mobile Engine installed that allows for *offline* working by downloading the data to the hard disk so as to be able to work when there is no Wi-Fi cover, as well as to synchronise all the information when entering a cover zone.

The software has 600 mobile terminals where the users manage, in three shifts, the maintenance operations of more than 70,000 items.

Fig. 6. This image shows data dumps for orders, operations and working groups of the GEMA mobile software.

Next we give a diagram where you can see the architecture used to develop the software applications with the SAP mobile engine [4].

The backend system built on SAP R/3 forms the nucleus of the Maintenance System. The maintenance agents access the system personally through a mobile client.

The mobile device does not have a permanent connection to the system backend, but rather it synchronises in certain situations, exchanging the selected information through the mobile client with SAP R/3.

The intermediary mobile server is capable of managing traffic between the mobile client and the system backend. The exchange of information between both environments is done by a BAPI/RFC interface and not by directly accessing the database. Only data modifications are transferred (delta or incremental synchronisation).
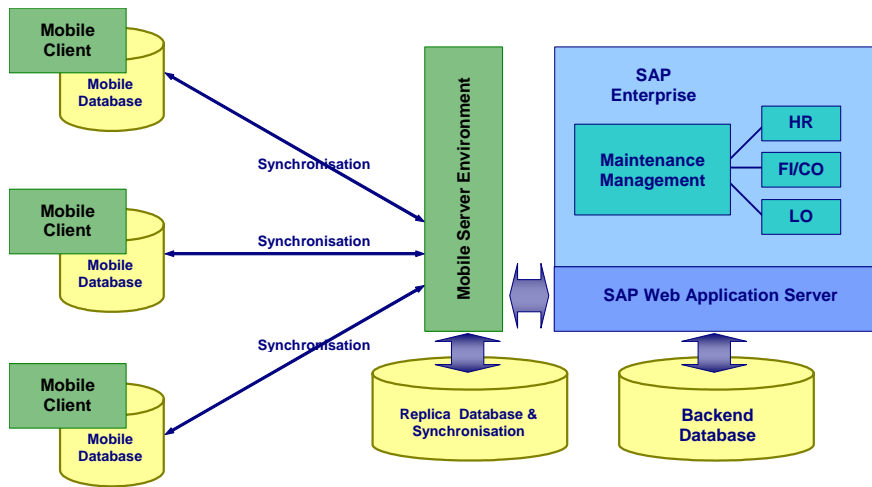
Fig. 7. Architecture of the SAP mobile engine technology.

Problems have been detected putting this software in action. They are, basically, due to roaming (changes of coverage zone and no cover), to the client which is heavily loaded and handles a large quantity of data for a mobile device. Another disadvantage is the life of the battery since in some cases it does not last for a working day.

The determining factor that we had with this application was due to not having total Wi-Fi cover in all the stations, but we hope to be able to resolve it by including full cover in all working zones, and in this way we could have a cut-down client in the terminals without the need to store large quantities of data in the terminal.

3.2 MTTCC (Mobility for Central Workshops)

This project introduced a mobile solution for Metro central workshops by integrating the SAP R3 PM and MM modules. This software provides greater automation of existing processes and considerably reduces errors due to the manual input of equipment and material codes.

The requirements for this software were to automate the incoming, outgoing and transfers of material in the central workshop and to update, automatically and in real time, the stock of materials. On the other hand, teams can be redeployed within the Central Workshops chain of command. Teams and material are identified by a barcode reader built into the terminal.

This application was developed based on SAP Netweaver Developer Studio (WAS server) and the program can be accessed online from the terminal through the web browser. The equipment is always connected by Wi-Fi to the Metro network and allows data to be updated from the terminal in real time, which is the most effective way and involves less administrative work.
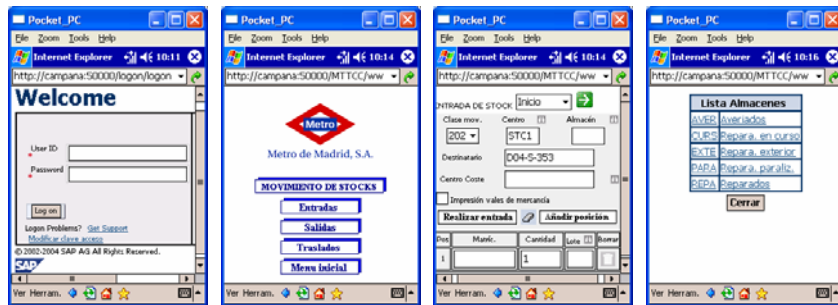
Fig. 8. Data dump of workshop software showing some functions.

4 Conclusions

Throughout these five years at Metro Madrid, we have been able to see the progress of "mobile technology" in all senses, both in development technologies, as well as in the progress of devices with better processors, greater memory capacity, operating systems, etc. The conclusion we have arrived at is that although a lot of progress has been made in all fields, we are still not in a stage of full maturity.

Some of the problems we have encountered basically arise from the instability of operating system and terminals, especially when working with complex applications that handle large quantities of information and use different connection modes to wireless networks. We have come across cases of blockages and rebooting terminals, which on some occasions was due to the Wi-Fi connection to the terminal, or to the batteries failing. We therefore consider that the technology is not yet mature.

Even so, we at Metro de Madrid are confident about this technology and we will continue to give our backing to equip the business to become more mobile, providing the company's agents wherever possible this year with new developments in mobile software for warehouses and for the maintenance of mobile material.

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